Ulasan Artikel /*Review Article*

Effects of Whole-Body Vibration Training as an Adjunct to Rehabilitation Exercise in Knee Osteoarthritis: A Protocol for Systematic Review and Meta-Analysis

Kesan Latihan Getaran Seluruh Badan sebagai Tambahan kepada Senaman Pemulihan dalam Osteoartritis Lutut: Protokol untuk Ulasan Sistematik dan Meta-Analisis

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ABSTRACT

Knee osteoarthritis (KOA) poses significant challenges, causing substantial impairment, disability, and healthcare costs. Whole-body vibration training (WBVT) is being explored as a potential treatment for KOA, but its efficacy remains uncertain due to inconsistent clinical evidence. This review aims to synthesize existing literature on the effects of WBVT as a supplementary intervention alongside conventional rehabilitation exercises in KOA management. The inclusion criteria encompass clinical trials investigating the combined effects of WBVT and rehabilitation exercises in KOA, published in either English or Chinese. Eligible trials will be identified through systematic searches across eight electronic databases, including PubMed, Web of Science, Embase, PEDro, SPORTDiscus, Scopus, ScienceDirect, and the China National Knowledge Infrastructure, from inception to May 2024. Data extraction will focus on WBVT parameters, rehabilitation exercises, and primary outcomes. Methodological quality will be assessed using the PEDro scale and Cochrane's risk of bias assessment. Meta-analysis utilizing RevManager software will synthesize continuous data on pain, physical function, and disability, presented via forest plots. This study seeks to comprehensively elucidate the synergistic effects of WBVT combined with rehabilitation exercises in KOA, a departure from previous reviews concentrating solely on WBVT effects. The findings aim to validate WBVT programs and assist healthcare practitioners in selecting optimal rehabilitation strategies for KOA management. Research outcomes will be disseminated in a peer-reviewed journal, with any methodological modifications explicitly addressed. This review will provide comprehensive evidence on the synergistic effects of WBVT combined with conventional rehabilitation exercises in KOA management. The findings are expected to support evidence-based integration of WBVT into clinical practice and guide healthcare practitioners in optimizing rehabilitation strategies.

Keywords: Exercise, Knee osteoarthritis, Meta-analysis, Rehabilitation, Systematic review, Whole-body vibration training

ABSTRAK

Osteoartritis lutut (KOA) menimbulkan cabaran besar kerana menyebabkan kerosakan fungsi, kecacatan, serta peningkatan kos penjagaan kesihatan. Latihan getaran seluruh badan (WBVT) sedang diterokai sebagai satu kaedah rawatan berpotensi untuk KOA, namun keberkesanannya masih tidak jelas berikutan bukti klinikal yang tidak konsisten. Ulasan ini bertujuan untuk mensintesis literatur sedia ada mengenai kesan WBVT sebagai intervensi tambahan bersama senaman pemulihan konvensional dalam pengurusan KOA. Kriteria inklusi merangkumi ujian klinikal yang menilai kesan gabungan WBVT dan senaman pemulihan dalam KOA, diterbitkan

dalam bahasa Inggeris atau Cina. Artikel yang sesuai akan dikenal pasti melalui carian sistematik dalam lapan pangkalan data elektronik iaitu PubMed, Web of Science, Embase, PEDro, SPORTDiscus, Scopus, ScienceDirect, dan China National Knowledge Infrastructure, dari awal penerbitan sehingga Mei 2024. Pengekstrakan data akan menumpukan pada parameter WBVT, senaman pemulihan, serta hasil utama. Kualiti metodologi akan dinilai menggunakan skala PEDro dan penilaian risiko bias Cochrane. Meta-analisis menggunakan perisian RevManager akan mensintesis data berterusan mengenai kesakitan, fungsi fizikal, dan kecacatan yang dipersembahkan melalui plot hutan. Kajian ini bertujuan untuk menjelaskan secara menyeluruh kesan sinergistik WBVT yang digabungkan dengan senaman pemulihan dalam pengurusan KOA, berbeza daripada ulasan terdahulu yang hanya menumpukan kepada kesan WBVT semata-mata. Penemuan ini dijangka dapat menyokong pengesahan program WBVT serta membantu pengamal kesihatan memilih strategi pemulihan yang optimum untuk pengurusan KOA. Hasil penyelidikan akan disebarkan dalam jurnal berwasit, dengan sebarang pengubahsuaian metodologi akan dilaporkan dengan jelas.

Kata kunci: Senaman, Osteoartritis lutut, Meta-analisis, Pemulihan, Ulasan sistematik, Latihan getaran seluruh badan

INTRODUCTION

Knee osteoarthritis (KOA) poses a significant health challenge (Peat & Thomas 2021), characterized by the progressive degeneration of knee joints, primarily due to wear and tear leading to the gradual loss of articular cartilage (Du et al. 2023). The primary symptoms of KOA include knee pain, swelling, limited mobility, stiffness, and functional impairment (Ahmad et al. 2018), all of which significantly impact daily activities and diminish the overall quality of life (Du et al. 2023). Globally, KOA has a reported prevalence of 16.0% and an incidence rate of 203 per 10,000 person-years, indicating a concerning trend (Cui et al. 2020). With the increasing prevalence of KOA worldwide, it imposes a substantial burden on individuals, healthcare systems, and society as a whole (Ackerman et al. 2019), emphasizing the urgent need for effective management strategies (Peat & Thomas 2021). Despite employing various modalities such as medication, physical therapy, and exercise in KOA management, achieving optimal outcomes remains challenging (Ahmad et al. 2022; Peat & Thomas 2021). Among the emerging therapies, whole-body vibration training (WBVT) has garnered attention due to its potential to enhance muscle function, aid in rehabilitation, and reduce the risk of sports-related injuries (Qiu et al. 2022; Wang et al. 2022).

Theoretically, WBVT entails utilizing motor-driven vibrating platforms, which transmit energy through the body, inducing changes in the length of the muscle-tendon complex and eliciting reflexive muscle contractions (Aminian-Far et al. 2011; Park et al. 2015). The mechanism behind WBVT is intricate, encompassing several physiological responses, including but not limited to: (i) induction of rapid muscle contractions through vibration stimuli, activating both voluntary and involuntary muscle fibers, thereby augmenting muscle activation compared to static exercise (Park et al. 2015); (ii) facilitation of motor unit recruitment and synchronization, fostering motor learning and neural adaptations, thus enhancing muscle performance (Aminian-Far et al. 2011; Park et al. 2015); (iii) elevation of growth hormone levels and reduction in cortisol levels (Park et al. 2015); and (iv) imposition of mechanical stress on bones, stimulating bone remodeling processes (Park et al. 2015). Its application in musculoskeletal disorders, including KOA, is increasingly explored (Wang et al. 2022). However, despite growing interest, the clinical efficacy of WBVT remains uncertain, with conflicting findings reported in recent randomized controlled trials. While some studies have demonstrated positive effects on pain (Wang et al. 2022), physical function, and disability (Zhang et al. 2021), others have shown no significant difference compared to conventional exercise interventions (Aggarwal et al. 2020; Bokaeian et al. 2016; Fernandes et al. 2020).

Existing systematic reviews have addressed the efficacy of WBVT in KOA (Li et al. 2015; Qiu et al. 2022; Wang et al. 2022); however, most have focused solely on its isolated effects without considering its integration with conventional rehabilitation exercises, which are the cornerstone of conservative KOA treatment. Moreover, methodological limitations and heterogeneity in WBVT protocols across studies have raised questions about the reliability and generalizability of findings (Imrey 2020). For instance, this study acknowledges a systematic review and meta-analysis conducted by Qiu et al. (2022), which encompassed five databases and analyzed 14 trials (Qiu et al. 2022). Their findings indicated that WBVT had additional positive effects on pain, knee extensor muscle strength, and physical function in KOA (Qiu et al. 2022). However, it's important to recognize that the control groups across the individual trials exhibited variations, and the review did not specifically address the impact of rehabilitation exercise, which is considered the primary recommended conservative treatment (Bannuru et al. 2019; Collins et al. 2019; Peat & Thomas 2021). Consequently, the differences in control groups may influence the outcomes,
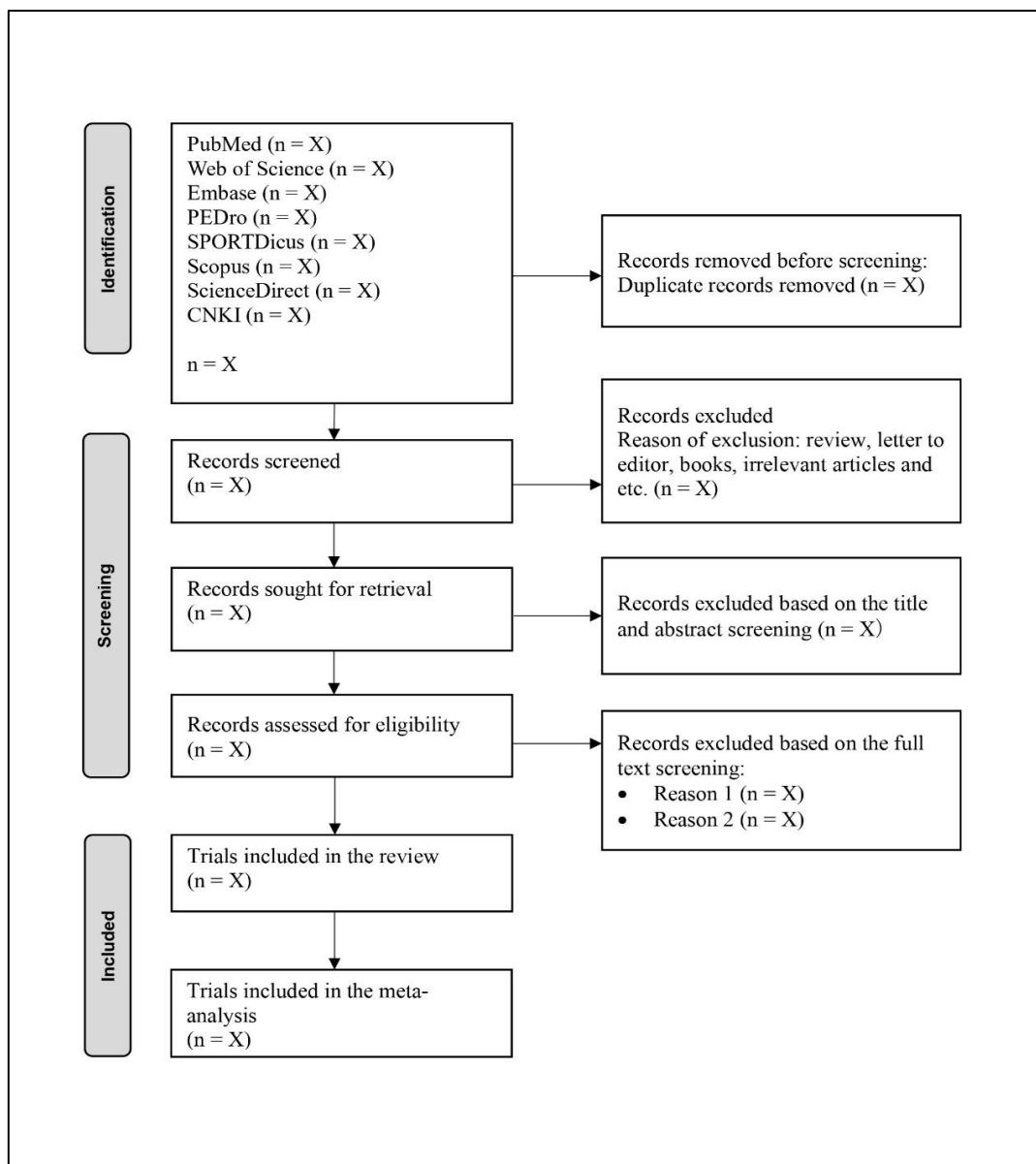
FIGURE 1 The PRISMA flow diagram.

particularly in the meta-analysis (Imrey 2020; Tawfik et al. 2019). To date, no systematic review has focused specifically on the synergistic effects of WBVT combined with conventional rehabilitation exercises for KOA, despite this combination reflecting real-world clinical practice. Therefore, this systematic review and meta-analysis aim to address these gaps by synthesizing existing literature on the combined effects of WBVT and conventional rehabilitation exercises in KOA management. This study represents an improvement in methodology, particularly in its specified context regarding WBVT as an adjunct to rehabilitation exercises, and in its comprehensive search across wide-ranging databases encompassing both English and Chinese language publications. By specifically focusing on this integrated approach, we aim to provide comprehensive insights into the synergistic effects of WBVT and rehabilitation exercises, which may offer valuable guidance for healthcare practitioners in optimizing KOA rehabilitation strategies.

MATERIALS AND METHODS

REVIEW PROTOCOL

This study was designed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher et al. 2015), and the protocol has been registered with PROSPERO (CRD42024508386). The primary review question guiding this study is: "What are the effects of whole-body vibration training as a supplementary intervention alongside conventional rehabilitation exercises on pain, physical function, and disability in individuals with knee osteoarthritis?"

SEARCH STRATEGY AND DATA SOURCES

To construct the search strategy, Medical Subject Headings (MeSH) terms and relevant keywords pertaining to KOA and WBVT were integrated, ensuring inclusivity of variations for each term. The selected keywords include 'knee osteoarthritis', 'gonarthrosis', 'arthr*', 'whole-body vibration', 'vibration', and 'WBV*'. Through the application of Boolean Operators 'AND' and 'OR', these keywords were combined to broaden the systematic search. Following preliminary investigations, the preferred search approach emerged as "(vibration OR whole-body vibration OR WBV) AND (knee osteoarthritis OR gonarthrosis OR arthr*)", which generated the highest relevance and quantity of hits.

The study will systematically search eight electronic databases: PubMed, Web of Science (WOS), Embase, PEDro, SPORTDiscus, Scopus, ScienceDirect, and the China National Knowledge Infrastructure (CNKI). The search strategy will be tailored to fit the syntax and functionalities of each database. Two authors will independently conduct the database searches using a standardized approach (Tawfik et al. 2019). The search will encompass the inception of databases to May 2024. Additionally, retrieved articles will be cross-referenced (Horsley et al. 2011). However, this study will not attempt to contact authors for additional information.

ELIGIBILITY CRITERIA

The following criteria will be applied for inclusion in this study, established based on the Population, Intervention, Comparison, and Outcome (PICO) framework (Tawfik et al. 2019): (1) randomized controlled trials; (2) the studied population comprises adults diagnosed with KOA according to the American College of Rheumatology criteria; (3) participants in the experimental group received WBVT and conventional rehabilitation exercises; (4) the control groups received conventional rehabilitation exercises; (5) studies with reported clinical outcomes including pain intensity, physical function, and disability scores; (6) regardless of the year of publication; and (7) published in English or Chinese language. Meanwhile, the exclusion criteria were clinical trials focusing solely on WBVT without a comparison group receiving conventional rehabilitation exercises, review articles, letters to the editor, articles published only as abstracts, and animal trials.

DATA SCREENING, SELECTION, AND EXTRACTION PROCESS

Two independent reviewers will conduct the initial screening of titles and abstracts based on the eligibility criteria outlined above (Tawfik et al. 2019). Full-text articles of potentially relevant studies will be retrieved and assessed for eligibility based on the inclusion and exclusion criteria. Any discrepancies will be resolved through discussion or consultation with a third reviewer. Data extraction will be performed using a standardized data extraction form, including the following details: study publication details (author, year), trial design (blinding, allocation concealment, and randomization), participants' characteristics (sample size, demographics, baseline characteristics), grouping and intervention details (WBVT parameters, rehabilitation exercise protocols) and main findings related to pain, physical function, and disability outcomes. A visual representation of the screening and selection process is provided in Figure 1.

RISK OF BIAS AND METHODOLOGICAL QUALITY ASSESSMENT

The methodological quality of the selected studies will undergo rigorous evaluation by two independent authors utilizing both the PEDro scale (de Morton 2009) and the Cochrane risk-of-bias assessment (Sterne et al. 2019). Any disparities in scoring will be resolved through thorough discussion until a consensus is reached between the reviewers. According to the PEDro scale, studies scoring six or higher will be classified as high quality, indicating a low risk of bias, while those scoring three or lower are deemed to be of low quality, suggesting a high risk of bias (de Morton 2009). Moreover, the Cochrane risk-of-bias assessment tool will be employed to assess bias across multiple domains, encompassing selection bias, performance bias, detection bias, attrition bias, reporting bias, and other potential biases (Sterne et al. 2019). Each domain will be scrutinized for its risk level: low, high, or unclear (Sterne et al. 2019). This comprehensive evaluation enables researchers to discern the reliability of study findings, facilitating informed interpretations within the framework of the systematic review. An example of the Cochrane risk of bias is illustrated in Figure 2.

META-ANALYSIS PROCEDURE

The meta-analysis will focus on key outcomes, primarily knee pain intensity, physical function, or disability level scores, utilizing post-intervention data (immediately upon intervention completion) where available. Continuous data will be meticulously handled, where means and standard deviations will serve as the primary metrics for calculating a standard mean difference (SMD)
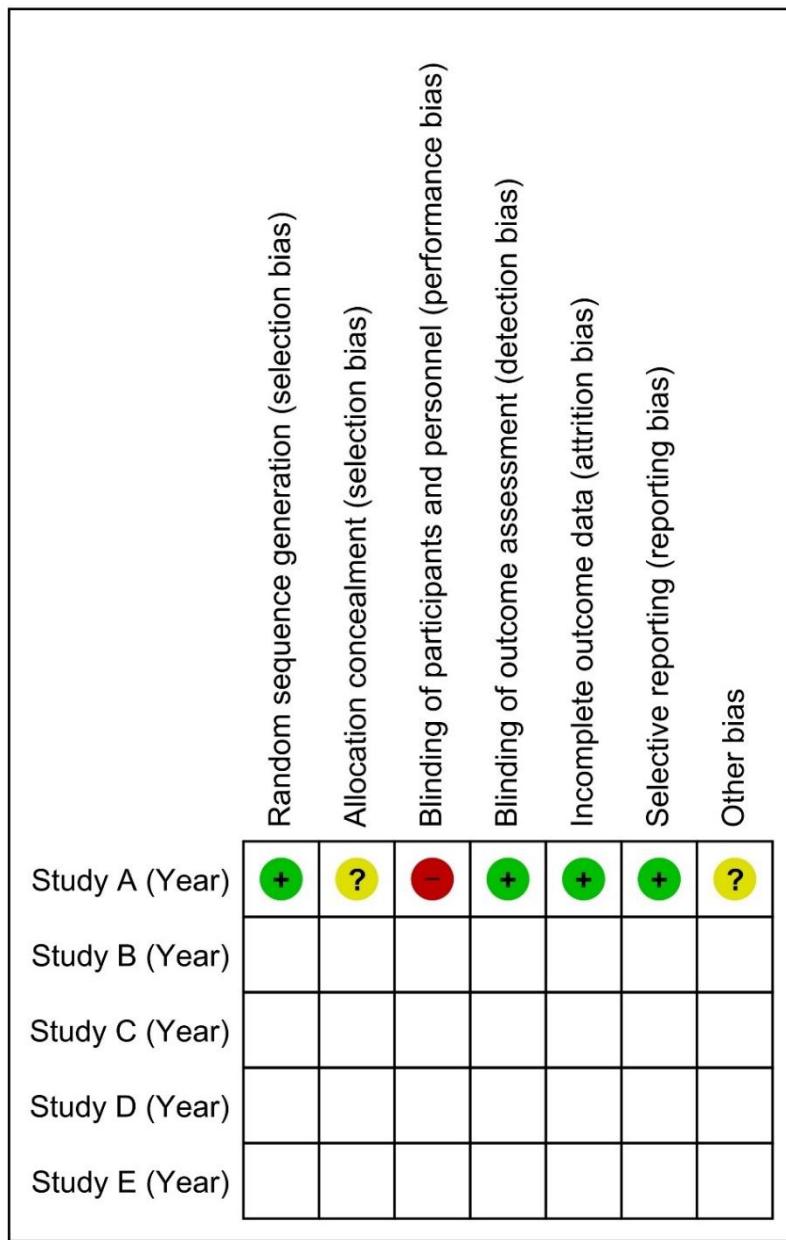
FIGURE 2 An example of summary of risk-of-bias analysis where '+' denotes low risk of bias; '?', unclear risk of bias; and '-', high risk of bias.
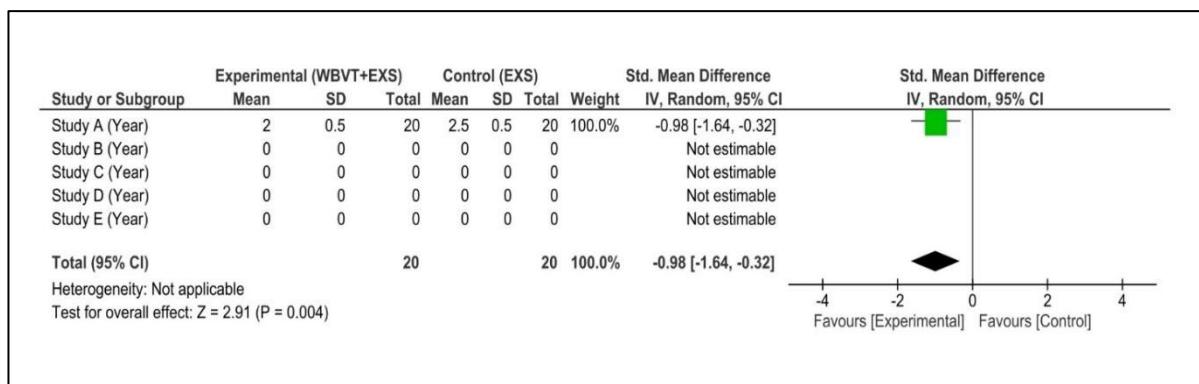

FIGURE 3 An example of a forest plot representing a meta-analysis.

alongside a 95% confidence interval (CI) (Tawfik et al. 2019). It's imperative to note that if studies report data differently, we will implement robust techniques to estimate mean (SD) values for uniformity across the analysis. This meta-analysis will be conducted independently by two reviewers to ensure reliability and consistency (Tawfik et al. 2019). Any discrepancies will be resolved through discussion and consensus to maintain methodological rigor.

Participant characteristics will undergo descriptive analysis at the group level using IBM SPSS Statistics software. The primary meta-analysis will be conducted utilizing Review Manager software (The Nordic Cochrane Centre), employing random-effects models to accommodate anticipated heterogeneity among included studies, particularly when significant heterogeneity ($I2 \geq 50\%$) exists (Tawfik et al. 2019). Sensitivity analyses will assess result robustness by excluding studies with a high risk of bias or small sample sizes (Tawfik et al. 2019). Additionally, subgroup analyses may be undertaken to explore potential sources of heterogeneity (Tawfik et al. 2019), such as variations in WBVT parameters or participant characteristics. A significance level of $P < 0.05$ will be set, with forest plots generated to visually represent meta-analysis results. Refer to Figure 3 for an example illustration of a forest plot in a meta-analysis context.

RESULTS AND DISCUSSION

The investigation of WBVT as a complementary intervention in KOA management presents a complex landscape, characterized by diverse study methodologies and conflicting findings (Aggarwal et al. 2020; Bokaeian et al. 2016; Park et al. 2013; Zhang et al. 2021). This systematic review and meta-analysis sought to elucidate the synergistic effects of WBVT when combined with conventional rehabilitation exercises, addressing a notable gap in the literature. By focusing on this aspect, the review aims to offer evidence-based recommendations to healthcare practitioners for optimizing rehabilitation strategies for KOA patients.

The synthesis of existing evidence in this review underscores the importance of considering WBVT within the context of broader rehabilitation strategies for KOA. Among the notable strengths of this study: (i) while previous reviews have predominantly examined WBVT in isolation (Li et al. 2015; Qiu et al. 2022; Wang et al. 2022), our analysis will specifically focus on its combined effects with rehabilitation exercises, (ii) comprehensive search strategy, which encompassed eight databases (significantly more than previous studies, typically covering four to six databases), and (iii) inclusion of both English and Chinese language publications (a departure from previous

reviews that focused solely on English literature). By adopting such an inclusive approach, we aimed to minimize the risk of publication bias and ensure a more representative sample of the available literature. However, despite these efforts, several limitations warrant consideration. The anticipated inherent heterogeneity among the included studies, including variations in WBVT protocols, patient demographics, and outcome measures, poses a challenge to data synthesis and interpretation (Imrey 2020). While sensitivity and subgroup analyses will be conducted to explore potential sources of heterogeneity, residual confounding factors may still influence the observed outcomes.

Furthermore, despite our proposed rigorous search strategy and protocol, it is possible that relevant studies may have been overlooked, particularly those published in non-peer-reviewed sources. Despite these limitations, the findings of this review offer valuable insights for clinical practice and research. Additionally, the identification of methodological gaps and areas for further investigation underscores the need for ongoing research to refine and optimize rehabilitation protocols in this population. The findings of this systematic review and meta-analysis will be disseminated through publication in a peer-reviewed journal and presentation at relevant conferences or scientific meetings. Additionally, findings will be shared with healthcare practitioners and policymakers to inform clinical practice and policy decisions related to KOA management.

CONCLUSION

This systematic review and meta-analysis will synthesize available evidence on the integration of WBVT with conventional rehabilitation exercises in KOA management. By elucidating the synergistic effects of WBVT, healthcare practitioners can tailor interventions to individual patients, potentially enhancing treatment efficacy, patient engagement, and adherence while optimizing healthcare delivery. Moreover, through dissemination in peer-reviewed journals and scientific conferences, we aim to foster knowledge translation and promote evidence-based practice, ultimately improving outcomes for individuals with KOA.

ETHICAL CONSIDERATIONS

Since this study involves the analysis of existing data from published studies, ethical approval is not required. However, ethical principles will be adhered to throughout the conduct of this systematic review and meta-analysis. Any amendments to this protocol will be documented and reported in the final manuscript, along with justifications for the changes.

DECLARATIONS

DATA AVAILABILITY

The datasets analyzed during the current study are available from the corresponding author upon reasonable request.

COMPETING INTERESTS

The authors declare no conflicts of interest.

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AUTHORS' CONTRIBUTIONS

Yan Peng and Mohd Azzuan Ahmad conceived the study, drafted the protocol. Chai Siaw Chui provided comments and revisions. All authors approved the final manuscript.

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